even in summer, can be inconvenient for small boats—unless properly designed —and a handicap to their gear-handling operations.

There is an old adage, reminding us that it's an ill wind that blows no one some good. This can be aptly fitted to the Caribbean, because the winds and choppy seas, which have been mentioned as bothersome in small-vessel operations, actually are benefical in fishing longline gear. From experience so far, it seems most likely that longline gear will be the principal, and probably the most productive device used in the open Caribbean for the development of fisheries for tuna and tuna-like species. There is rather good reason to believe that this gear fishes far more effectively at times when there is surface wave action.

On the basis of preliminary examination of results of 175 longline sets, made in the Gulf and Caribbean during exploration by the vessel OREGON, catches in moderate seas were 35 per cent better than in calm seas. Catches in heavy seas were 23 per cent better than in calm seas. We are not certain as to the reasons for this. Perhaps the surface waves create enough longline movement so that the baits are more active and, therefore, more attractive to the fish; perhaps it is the agitation of the water which churns up the general food supply. One thing we know for certain is that the wind and the waves are factors to be considered in Caribbean fishery development.

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The Lobster Fishery of Puerto Rico

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Introduction

THE SPINY LOBSTER, *Panulirus argus* Latreille, has a considerable local importance to both the commercial and sport fisheries of Puerto Rico. The commercial landings are worth around $100,000 per year to the fishermen, and according to Erdman and Zalduondo (1956), records of 37 spearfishing trips collected at the port of Joyuda showed that this species represented 43 per cent of the catch by number and 16 per cent of the catch by weight of the sport spearfishermen landings. The increasing demand for this item has made necessary its importation from other countries.

This paper is the result of a study undertaken since 1955 by the Division of Forests, Fishery and Wildlife of the Department of Agriculture and Commerce of Puerto Rico for the purpose of ensuring a better management of the fishery, and of furnishing reliable information to the inquiries which this agency receives both locally and from abroad.

Description of the Fishery

The spiny lobster fishery of Puerto Rico has a comparatively recent origin, having attained economic importance around 1947. From that year on, the production increased considerably up to 1951. A probable decrease took place after that date, as shown by evidence found at Puerto Real and Culebra, the two most important production centers. This is probably due to the natural fluctuation in a virgin area.

The spiny lobster is fished around the whole Island of Puerto Rico, but the most important fishing grounds are located on the western and eastern coasts, which have a larger shallow area. (See Fig. 1).

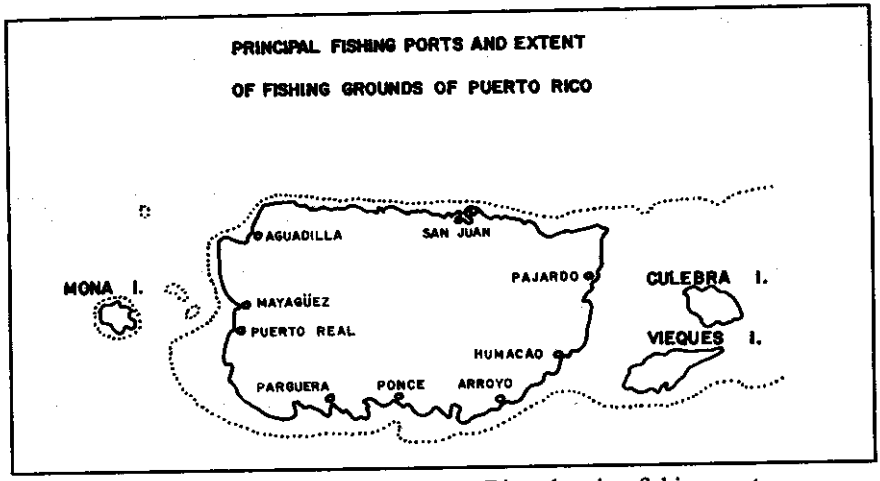

FIGURE 1. Outline map of Puerto Rico showing fishing ports and extent of fishing grounds.

The boats employed in this fishery are of wooden construction. They are locally manufactured, native timbers with natural bend being used for stems, ribs and sterns, and only wood for planking being imported. They are strongly built and well kept. Three types of boats are used: rowboats, sailboats and motorboats. The rowboats are of the dory type, most of them flat bottomed, ranging in length from 10 to 18 feet. The sailboats are decked, usually having a live well for holding the lobsters. They are sloop-rigged vessels ranging in length from 15 to 35 feet. Few motorboats are employed at present, but their number is increasing. There are two types in use, a keeled skiff having an outboard motor of 5 to 10 HP, and equipped with a live well, and a decked and bigger boat of the class generally used for harbor work. This is not specially adapted for fishing, but it can cover long distances in less time and is not so dependent on the weather conditions.

Several types of fishing gear are employed, of which traps are the most im-

portant. There are two types of traps, wire and wooden traps. The wire trap, locally known as "nasa," is in general use throughout the Island. It is made in the shape of a broad arrowhead, and it varies in length from three to six feet, being three feet wide and eighteen inches high. It consists of a wooden framework made of mangrove wood, covered with galvanized chicken wire. The complete apparatus, consisting of the wire trap equipped with buoy lines and floats, has an average cost of $7.50. This trap lasts around twelve months. The wooden trap or "cajón" is of a type modified from that used in Florida, being rectangular or square in shape, but tapering from base to top. It has a base of approximately three to four square feet, and a height of two feet. It consists of a framework of mangrove wood covered with bamboo laths spaced 1½ to 2 inches apart. It has an average cost of $3.00, including the buoy line and the floats. It lasts around eight months, and except for a few fish which have no commercial value, its catch consists exclusively of lobsters. Both the wire and the wooden trap are fished at depths from 3 to 20 fathoms.

According to Iñigo (1952) there was a total of 223 fishermen employed in the spiny lobster fishery in 1951. This number has probably remained more or less the same since then.

The fishermen bring in their catch alive by means of live wells, or in damp jute sacks. The wholesalers usually have agents in each port who purchase the lobsters and keep them alive in live cars until an adequate amount for shipment is available. The lobsters can remain there for weeks provided that they are not too crowded and that they are provided with enough food. When the time comes they are transported alive in damp burlap sacks to the wholesaler's establishment, where they are sold to retailers or to hotels and restaurants, alive or frozen, either raw or boiled. At present lobsters are not canned or processed in any other form. After being boiled, the entire animal is sold frozen, since the meat from the head and legs is also used by the consumers for the preparation of salads and soups.

Production Statistics

The estimation of the true economic importance of this fishery, and the determination of trends within its production must be based on an efficient system of collecting fishery statistics. Such a system has not been employed in any of the Puerto Rican fisheries, and its establishment would take some time in a fishery like this, which is based on small catches landed at different localities and sold through different dealers who do not keep any books most of the time. The only information available is that furnished by Iñigo (op. cit.) in his survey of the fisheries in 1951, and that collected recently at Culebra, Puerto Real and La Parguera for the purpose of this work. Most of the data were collected at the fishing center of Culebra Island, because, besides being the second in production, its landings are centralized, a fact which facilitates the taking of information. Since the development of this center started in 1948, the data available should be sufficient for its appraisal.

Iñigo reported the catch of the whole lobster fishery of Puerto Rico during 1951 to amount to 466,760 pounds, valued at $87,333 to the fishermen. According to this author, the figure reflects the sharp increase in lobster production which had taken place since 1947. There is evidence to support the idea that there has been some decline in the catch since 1951, even though its value

might have remained more or less the same due to the increase in price. The present price per pound paid to the fishermen ranges from $0.25 to $0.35, and there are even some dealers who have paid as much as $0.40.

The demand for this product has increased and, as can be observed in Table 1, there has been a rise in the importations in the last few years.

TABLE 1

IMPORTS OF LOBSTERS (NOT CANNED) INTO PUERTO RICO
1950-51, 1954-55, and 1955-56.

Year	*Country*	*Pounds*	*Value*
1950-51	Netherland Antilles	2,923	$ 1,150
	French West Indies	880	308
	Total	3,803	$ 1,458
1954-55	Ecuador	5,714	$ 1,851
1955-56	Ecuador	1,890	$ 1,253
	Mexico	493	304
	Cuba	13,309	4,730
	Leeward & Windward Islands	2,060	534
	Total	17,752	$ 6,820

Fluctuations in the lobster production of the banks of Culebra Island are possibly caused both by biological and non-biological factors. As a general rule, the peaks of production seem to occur around the months of November and December during the winter, and around the month of May during the summer. A possible explanation of the winter peak could be the migration into the fishing area of large lobsters coming from deeper waters, probably due to rough weather. This is the period of ground swells of "rebosos," which the fishermen look forward to, since high catches are made after periods of bad weather. The catch per unit of effort increases, and the average lobster is heavier than during previous months. The summer peak could possibly be caused by a higher congregation of lobsters related with breeding activities.

There is an abrupt fall in the production at Culebra during the months of January, February and March. This decline coincides with the period of maneuvers of the U. S. Navy which takes place in those waters, during which time the fishing area is reduced to two or three miles off its southern coast. Even though there is no doubt that this reduction in the fishing area and in the fishing effort is the main causative factor in the considerable drop in the landings, this does not rule out the possibility that some biological factor might also be involved. The general picture presented by this region is that of a typical virgin area which, when subjected to exploitation, is characterized by a high yield, older animals being predominant in the catch. In this case more fishermen were attracted to the fishery, with the subsequent increase in effort producing a still higher yield in the second year. This temporary increase was followed by a sharp decline during which some fishermen started leaving the area due to the decrease in the catch per unit of effort. Finally the fishery seemed to reach a state of

equilibrium in 1955, the fishing pressure remaining more or less constant since then. The decrease in production since 1951, therefore, is probably due to the natural behavior expected in a new fishery, and not caused by depletion. The possibility exists also that this picture might prevail in the other lobster areas of Puerto Rico.

The estimation of fishing effort was determined using as unit the catch per lift per trap. This catch per unit of effort was found to be 3.6 pounds for the wooden trap, and 2.5 pounds for the wire trap. Dawson (1949), in his study of the lobster fishery of Florida, reported the average catch per wooden trap in a string of 100, to be six crawfish. According to this author the lobsters caught by those traps had an average weight of 1¼ pounds, bringing the production per trap to about 7.5 pounds. This catch is approximately 2.1 times the production of our wooden trap and three times that of the wire trap. This catch per unit of effort should be regarded as an indication of availability rather than of abundance, since the lobster population is characterized by a seasonal pattern of movements upon which is superimposed an erratic movement associated with foraging and weather, the animals sometimes moving beyond the range of the fishery.

TABLE 2

CATCH PER UNIT OF EFFORT, 1956-57
(In Pounds of Lobsters)

Month	Wooden Trap	Wire Trap
July	3.0	3.0
August	2.9	3.3
September	1.7	—*
October	2.2	—
November	5.5	—
December	—	6.5
January	5.7	2.3
February	4.4	1.2
March	4.2	0.6
April	2.5	0.9
Average	3.6	2.5

*Figures unobtainable.

The fact that two different traps are used at the Island of Culebra presents an unique and interesting opportunity of establishing a difference in their relative efficiency and selectivity. This difference, besides affecting the estimation of catch per unit of effort and other statistics, can be of economic importance to the fishery. (See Table 2). The comparison of gears was made over a full year. The wooden trap was found to be selective on smaller sizes, and to produce a higher number of lobsters than the wire trap, catching an average of 1.9 lobsters per lift, with an average weight of 1.8 pounds per lobster. The wire trap caught an average of 1.2 lobsters per lift, with an average weight of 2.7 pounds per lobster. According to the data collected, the wooden trap produced a catch valued at an average of $0.89 per lift. The average lobster production of the

wire trap was found to be $0.62 per lift, which added to an average fin fish production of $0.22 per lift, raised its total production to $0.84. Traps are lifted normally every three days, resulting in an average of ten lifts per month, which would bring the total production per month to $8.90 and $8.40 respectively. Deducting from these figures the monthly cost and depreciation, a net income results of $8.40 per wooden trap and $7.15 for the wire trap. This net income is 16.8 times greater than its monthly cost and depreciation in the case of the wooden trap, and only 5.7 times greater in that of the wire trap. Based on these observations of its efficiency, 15 wooden traps have been bought by the Division of Forests, Fishery and Wildlife to be introduced experimentally on the western coast of Puerto Rico at the end of this month.

Biology

The general biology of *Panulirus argus* in Puerto Rico is similar to that described for this species in other areas of its range. It is primarily a scavenger inhabiting areas offering natural protection.

The sex ratio was found to be 50:50, a similar condition to that found by Dawson and Idyll (1951) in Florida; nevertheless, males were predominant in the spearfishermen catches. Sexual maturity seems to be attained when females reach a carapace length of 3.4 inches, or a total length of approximately nine inches.

Females carrying spermatophores and eggs were observed at all months. What could be called the peak of the spawning and mating seasons occurred from April to June, the percentage of worn spermatophores and mature eggs increasing after those months. (Table 3 and Fig. 2).

TABLE 3

SEX RATIO AND BREEDING DATA OF SPINY LOBSTERS FROM CULEBRA, PUERTO RICO

June, 1956 - April, 1957

Month	Males	Females		Females With Eggs		Females With Sperm	
	No.	No.	%	No.	%	No.	%
June	24	37	39	17	46	33	89
July	291	271	48	112	41	243	90
August	451	381	46	149	39	285	75
September	—	—	—	—	—	—	—
October	110	130	54	45	35	78	60
November	69	83	55	28	34	60	72
December	87	79	48	9	11	53	67
January	56	60	52	16	17	31	52
February	42	27	39	13	48	20	74
March	30	27	47	14	52	21	78
April	45	31	41	20	65	21	68
Totals	1,205	1,126					

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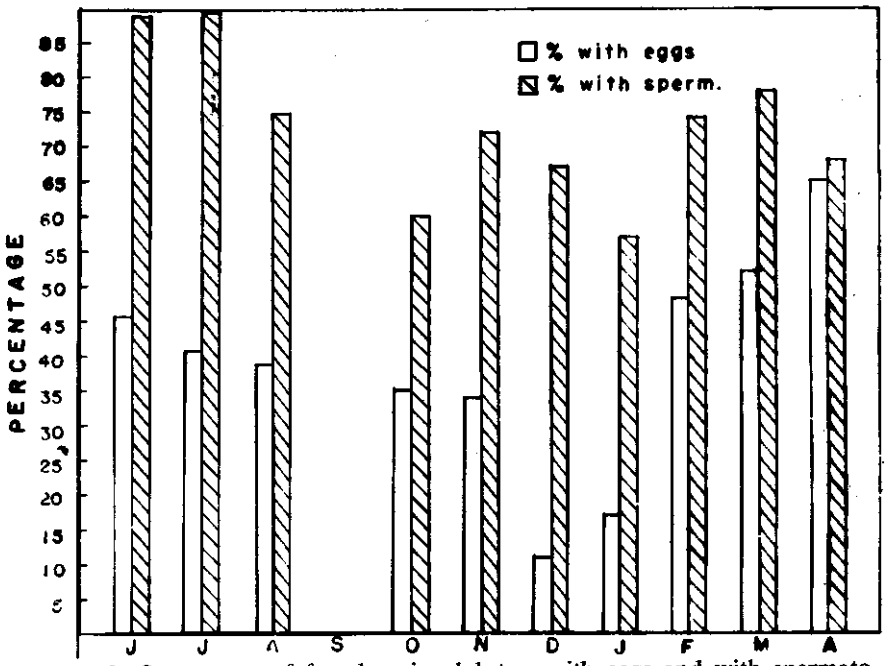

FIGURE 2. Occurrence of female spiny lobsters with eggs and with spermatophore expressed as a percentage of the total number of females from June through April. Culebra, P. R. 1956-57.

The number of eggs laid by the lobster was found to range from 434,000 to 1,691,000, with an estimated average of 933,000 eggs. The number of eggs was found to increase with the size of the animal, although several large specimens were found to have a lower number of eggs than would be expected. This number of eggs calculated for the lobster in Puerto Rico seems to approach the results obtained by Creaser (1950) for the same species in Bermuda.

The average weight of the market lobster in Puerto Rico was found to be two pounds, with an average size of 11 inches of total length. The average weight of the males was 2.3 pounds, while that of the females was 1.7 pounds. Mattox (1952) reported an average length of 12.02 inches, and an average weight of approximately 2.56 pounds (this last figure was calculated using his average weights for males and females). His figures are not only higher than the averages presented above, but they are also higher than our averages of September and October, the months covered in his studies. Nevertheless, he reports the 1.5 pounds size to be the size-group of greatest frequency in the females, and that of 2.25 pounds for that of the males, these size-groups being the same found to be most prominent by the writer. This would suggest that even though there has been a drop in the average size and weight of the lobsters in Puerto Rico, probably due to the elimination of the larger animals, the population composition has remained more or less the same. Figures 3 and 4 illustrate the total length-carapace length and the weight-lengths relationships of the spiny lobster in Puerto Rico.

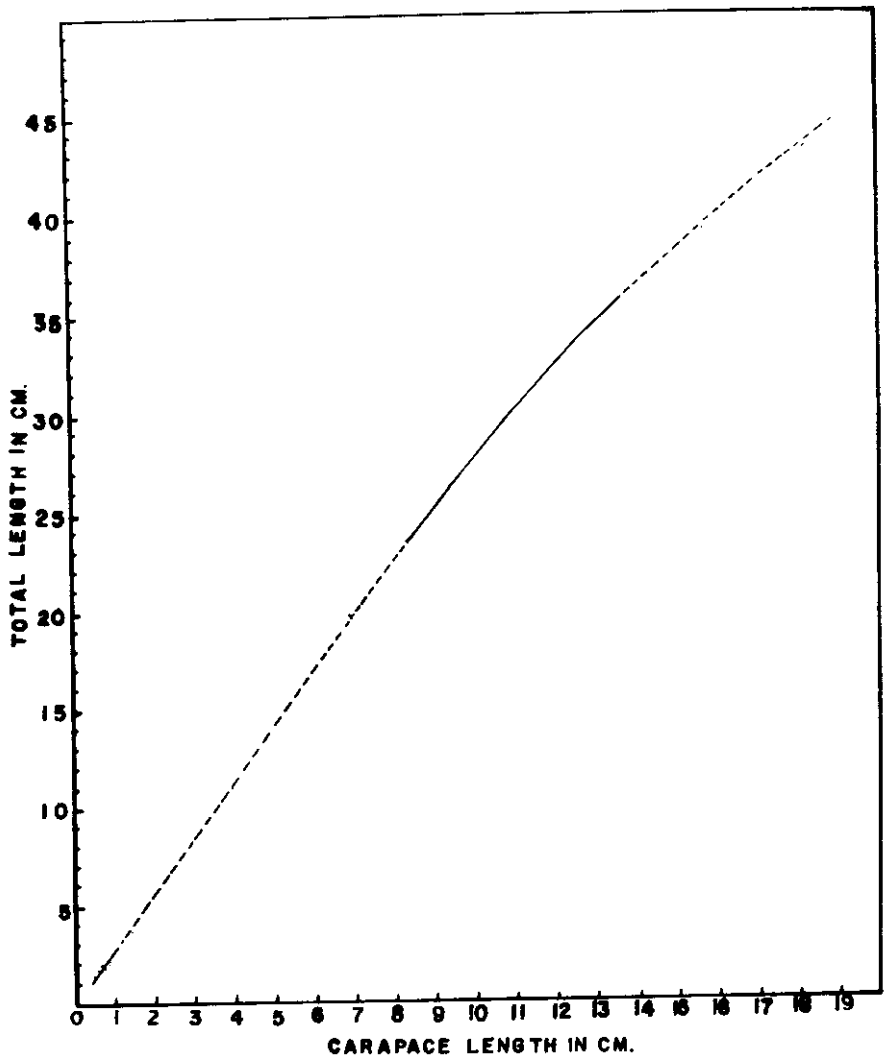

FIGURE 3. Total length—carapace length relationship of the spiny lobster *Panulirus Argus* from Puerto Rico.

Regulations and Other Considerations

The only protective regulation concerning the spiny lobster in Puerto Rico forbids the taking, killing, destruction, possession or selling of berried females during any month of the year. Considering the fact that, as postulated by Smith (1948), in species like the spiny lobster having a high fecundity, the reproductive potential would probably not be endangered by heavy fishing until the fishery itself had become economically unsound, and based on the results of

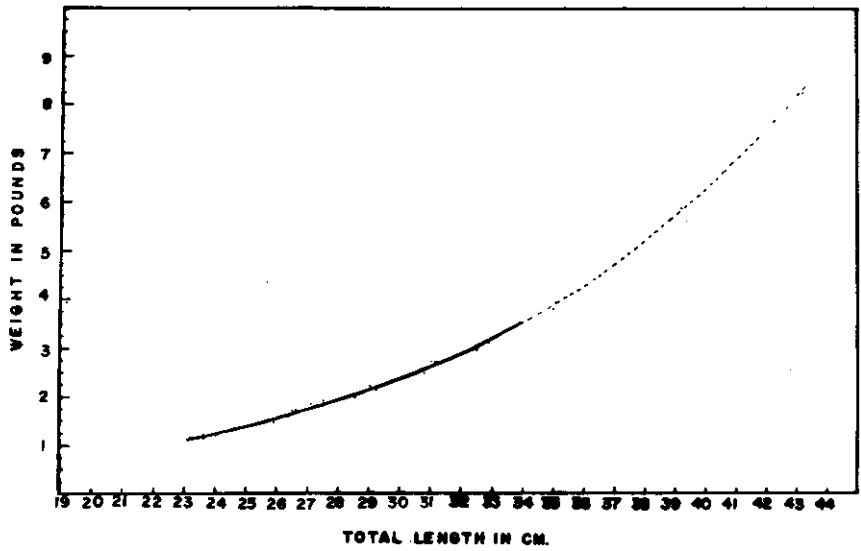

FIGURE 4. Weight-length relationship of the spiny lobster *Panulirus Argus* from Puerto Rico.

this study, it has been recommended that this regulation be abolished. Besides having a doubtful value as a conservation measure, its enforcement curtails the production because of the considerable percentage of berried females present throughout the year. The only regulation which would seem more practical at present would be the establishment of a minimum size-limit similar to that proposed by Dawson and Idyll (1951) for the lobster in Florida, that is nine inches in total length or a carapace length of 3.5 inches. This legal size would prevent the taking of immature females.

The most important step that should be taken in relation to the conservation of this fishery would be the adoption of a statistical system by which accurate measures of catch and fishing effort could be taken.

Further development of this fishery would depend on expansion of the fishing grounds, especially those on the eastern coast, motorization of the fishing fleet, and improvement of the handling and processing methods.

It is probable that we could be dealing with a single population in Puerto Rico, but further investigation would be needed to establish this possibility.

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Historical and Economic Aspects of the Shark Fishery of the Pacific Coast of Mexico

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FISHING IS ONE OF MAN'S OLDEST OCCUPATIONS and science tells us that sharks were known to exist even farther back in geologic time than the Devonian Period of 355,000,000 years ago. It is safe to assume, then, that shark fishing is as old as man. Today a hundred or more different species of sharks populate the oceans along the coasts of every continent. Feared and spurned as a dangerous and predatory inhabitant of the sea, and ignored as worthless in many lands, it is sought as an important source of food and other useful products in other countries.

This paper will recount facts and knowledge obtained from many years in the fisheries of the Pacific Coast of Mexico. The shark fishery had its inception in 1939 and went through a great development which resulted in a full scale fishery in 1950. The writer has been associated with this fishery from the beginning.

The Pacific Coast of Mexico, with its 4,000 miles of coastline, has more than its share of the world's shark population, including many species. People of old civilizations before the Spanish Conquest were not a seafaring folk. Hence the shores were sparsely populated and fishing was limited to a simple activity close to shore that produced sharks of the smaller species, such as the dog fishes, locally known as "Cazon," and still very popular sold fresh. The same may be said of the four centuries of Spanish rule and the Republic later, when small progress in the fisheries in general was recorded.

The only true commercial shark fishery in Mexico, up to the second World War, was centered at La Paz, in the southern half of the Lower California Peninsula, inside the Gulf of California. The first white settlers of this beautiful but inhospitable waste of land, practically isolated by land and sea, were Span-